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3-D forward calculation and inversion of magnetotelluric data using the meshes including the actual topography

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The author developed a 3-D MT inversion code using unstructured tetrahedral elements and a tool to make computational meshes including the actual topography from digital terrain data.

It is important to consider topographic effects in interpreting observed data of magnetotelluric (MT) method. Without ignoring these effects, it is, therefore, possible to misinterpret subsurface structures because the observed data from MT surveys can be strongly affected by the topography around the survey area. The most straightforward way to take account of these effects is to incorporate the topography explicitly in the computational grid used in forward calculation and inversion, and this method can be applicable to a wider range of surveys.

Among space discretization methods, the finite element method using the unstructured tetrahedral element is considered to be one of the most effective method to include topography in computational grids, because it can represent topography precisely without using too many elements, and a number of robust meshing algorithms have been proposed such as Delaunay triangulation method and the advancing front method.

The forward part of the developed inversion code uses the edge-based tetrahedral element to calculate the electromagnetic field on the earth's surface. The inversion code can use the impedance tensor, the vertical magnetic transfer function and the phase tensor as observational data, and it estimates the subsurface resistivity values by updating them using Gauss-Newton method.

To make 3-D computational mesh of model, the tetrahedral mesh generator TETGEN (Si 2007) was used. This program constructs a tetrahedral mesh by the constrained Delaunay triangulation method from an inputted piecewise linear complex (PLC). Thus, in order to make a 3-D mesh containing topography, the author developed the program which makes the PLC including the topography. First, this program makes the 2-D mesh including land-sea boundaries by the 2-D constrained Delaunay triangulation method from the data of coast lines. Next, the altitude of the water depth of each node of the mesh is interpolated from topographic data by the inverse distance weighting method, and then outputs the 3-D PLC containing the topography.

With the aid of the inversion code and the meshing tool, the author will perform forward calculation and inversion using the mesh including actual topography to evaluate the topographic effects precisely and interpret subsurface resistivity structures accurately.